Unit 3 Lesson IV (3.4)
Energy Changes in Nuclear Reactions

Objective: The student will be able to calculate the amount of energy generated in a nuclear reaction.

Homework: Mass-Energy Problem Set

The Law of Conservation of Mass-Energy

$$E = mc^2$$

Einstein showed in the early 20th century the relationship between mass and energy.

The traditional mass and energy conservation laws have been combined to state that *the total quantity of mass energy in the universe is constant.*

This means that knowing the mass of a substance and the constant "c" we can calulate a certain energy.

Energy Changes in Chemical Reactions

In chemical reactions, we say that there is a conservation in mass. The truth is that there is a change in mass. Consider when 1 mol of water breaks up into its atoms:

$$H_2O_{(g)} \rightarrow 2H_{(g)} + O_{(g)}$$

The change in mass (as calculated from Einstein's equation) is: $\Delta m = 1.04 \times 10^{-8}$ g/mol and is so small (or negligible) that we make an assumption that mass is conserved.

A mass change this small cannot even be detected by our most sophisticated instruments.

Energy Changes in Nuclear Reactions

When dealing with Nuclear Reactions, we are not granted this same luxury:

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

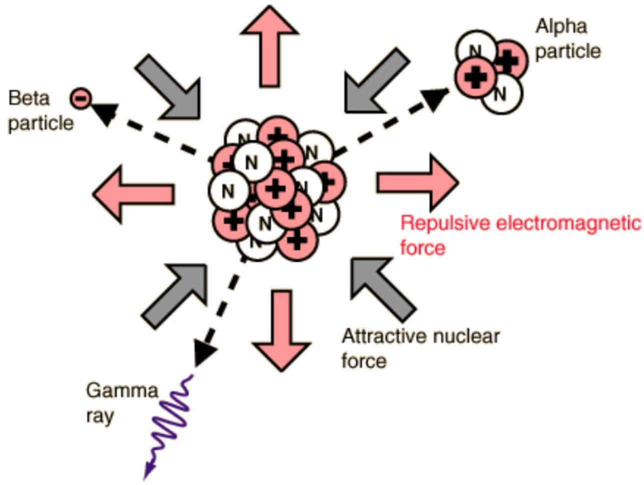
masses (amu):	**238.0003**	**233.9942**	**4.0015**

$$\Delta E = (\Delta m)c^2 = (-4.6x10^{-6}kg)(2.9979x10^{8}m/s)^2$$

$$\Delta E = -4.1x10^{11}\ J$$

Binding Energy

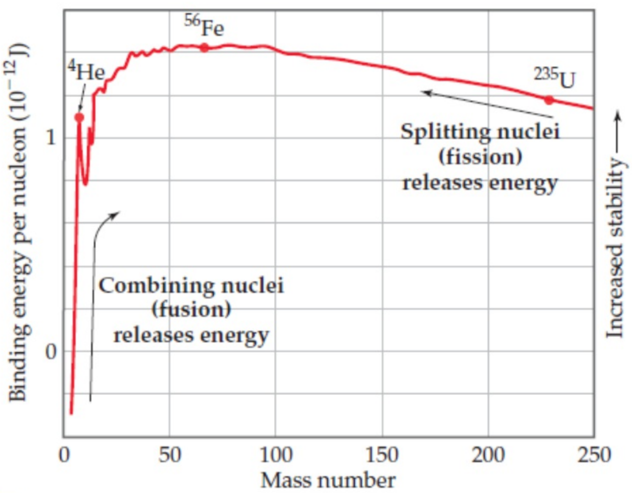
Definition: the mechanical energy required to disassemble a whole into separate parts.



Nuclear binding energy: energy liberated when a nucleus is formed from another nucleus or nuclei or the energy required to disassemble a nucleus into the same # of free, unbound neutrons and protons of which it is composed.

An atomic binding energy would be the energy required to disassemble an atom into free electrons and a nucleus.

Trends in Nuclear Binding Energies



<u>Significant Consequences:</u>

1. heavy nuclei gain stability and give off energy when they fragment into two mid-sized nuclei.

2. Greater amounts of energy are released when light nuclei are fused to give more massive nuclei.

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Uuu	Uub	Uut	Fl	Uup	Lv	Uus	Uuo
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

The second process is energy-producing process in the Sun.

Stars **Supernovae** **Synthetic**

Example #1

Calculate the mass defect for a mole of hydrogen-2. The measured mass of 1 mol of H-2 is found to be 2.01355.

mass (p^+) = 1.00728g
mass (n^0) = 1.00867g

Example #2

When Co-60 undergoes beta decay, how much heat is released?

The mass of Co-60 is 59.9338 amu, the mass of Ni-60 is 59.9308 amu, and the mass of an electron is 0.000548 amu.